

Identifying barriers to ethnic/racial minority students' participation in graduate physics

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Historically, access to education in the U.S. has not been equitable. Furthermore, intersectionality, the interaction of multiple identities, results in educational experiences that vary widely for diverse groups of students with implications for the recruitment of future students. To better understand barriers to ethnic/racial minority students participating in graduate education a study has been conducted through the APS Bridge program, a program designed to increase the number of ethnic/racial minorities earning PhDs in physics. In phase one of this study, we analyzed student responses to an application question regarding why they chose not to apply to graduate physics programs. To further understand the barriers identified in the first phase of this study, we interviewed nine participants in the 2016 Cohort of the APS Bridge program. The results of this study have implications for a variety of stakeholders interested in broadening participation in graduate physics education.

I. INTRODUCTION

As the nation aims to satisfy the science, technology, engineering, and mathematics (STEM) workforce demand, broadening participation in STEM through the recruitment and retention of women and ethnic/racial minorities has received much attention. The President's Council of Advisors on Science and Technology referred to women and members of minority groups as "an expanding pool of untapped talent" in the nation [1]. Recent research has taken an intersectional approach to investigating how to broaden participation in physics. One study explores factors of persistence and success and navigational strategies used by women of color in physics and astronomy to advance in their academic and professional careers [2]. Another study investigated the impact of the intersection of race, gender, and science on undergraduate women of color in physics that persevered through their programs and remained in physics after completing their degrees [3]. Rosa and Moore Mensah examine the lived experiences of Black women physicists with PhDs [4]. A climate survey and in-depth interviews with individuals who self-identify as LGBT in physics revealed that LGBT physicists with additional marginalized identities faced greater levels of discrimination and that transgender and gender-nonconforming physicists faced the most hostile environments [5].

The authors of this study seek to contribute to the growing body of literature on broadening participation in physics that utilizes an intersectional perspective by focusing on an often-overlooked population of potential PhD physicists: students that earn bachelor's degrees in physics, but do not apply to graduate school. The fraction of underrepresented ethnic/racial minority students earning bachelor's degree in physics is nearly twice that of underrepresented ethnic/racial minority students earning PhDs in physics [6].

To better understand the barriers ethnic/racial minority students with bachelor's degrees face in applying to physics graduate programs, we seek the perspective of those who demonstrated interest in pursuing a PhD in physics, but ultimately chose not to apply.

II. RESEARCH DESIGN

In Phase 1 of this study, students' responses to an application question regarding intent to apply to graduate school as part of the APS Bridge Program (APS-BP) application were coded [7]. In Phase 2 semi-structured in-depth interviews were conducted with students accepted into graduate physics programs through the APS-BP.

A. Context: The APS Bridge Program

The APS-BP aims to increase the number of African American, Hispanic American, and Native American students obtaining PhDs in physics. APS-BP offers a free, common application that is shared with numerous physics graduate programs, professional development for students, as well as connections to faculty mentors and other students placed in bridge programs nationwide. Students eligible to apply to this program must have completed a bachelor's degrees in physics or a closely-related discipline and have either chosen not to apply directly to graduate physics programs or have applied, but were not accepted. Participants in this study include applicants to the APS-BP (Phase 1) and accepted students in the first year of their graduate physics programs (Phase 2).

B. An Intersectional Perspective

Intersectionality [8] grew from a "critical mass of scholars of color" in law, many of whom had backgrounds in ethnic studies, black feminism, and community activism, concerned with the way that identities and power interacted

with the law [9]. Although it acknowledges that people have multiple identities, it is concerned with “the way things work rather than who people are [10].” An intersectional perspective was used in the analysis of the data from this study. Intersectional perspectives recognize “the multiple interlocking identities that are defined in terms of relative sociocultural power and privilege and shape people’s individual and collective identities and experiences [11].” Thus, in this study we sought to understand the experiences and perspectives of the participants with a focus on how their multiple interlocking identities impacted their decisions not to apply to graduate physics programs. Due to constraints of space, in this paper we present the themes found and highlight the relevant identities rather than discuss the interlocking identities of each individual participant. Although all participants interviewed in Phase 2 identified as either Black/African American or Hispanic, our analysis includes other identities they disclose and how these might relate to their perspectives on graduate physics programs.

C. Data Analysis

In Phase 1, we analyzed responses to a yes/no question on the APS-BP application: Have you applied to any graduate programs? Between 2013 and 2016, 95 applicants indicated interest in pursuing a PhD in physics, but selected “no” as a response to the yes/no question. Of those students, 81, all from 2014-2016 provided an open-ended response to the follow-up question, “If no, please explain the reason for not applying.” Applicants were not required to respond to the open-ended question in 2013; and none of them chose to respond. 2014-2016, the open-ended question was a required part of the application. Responses to this question provided the data for Phase 1. Responses were coded using open coding and then collapsed into the themes discussed in the findings. Applicant responses to this question ranged from 6 to 545 words, with the average being 15 words. Thus, semi-structured interviews were necessary to expound further on the themes found.

In Phase 2, semi-structured interviews were conducted with nine students accepted into the APS-BP and enrolled in physics graduate programs. All 20 students from the APS-BP 2016 Cohort were invited to interview between the close of the fall 2016 academic semester and the start of the holiday season, 9 participants indicated interest and were available. In phenomenological research, a qualitative research approach, the goal is to describe the common meaning for several individuals of their lived experience of a concept or a phenomenon [12].” In this case the shared experience of participants was having a desire to pursue a PhD, but feeling that they could not apply or would not be accepted. Recommendations for sample size in a phenomenological study range from 3 to 10 subjects [12]; thus, we felt 9 interviews was sufficient for this study. “The interview protocol consisted of five main

questions/prompts, 1) *When did you first start thinking about graduate education/graduate school in physics?* 2) *Did you discuss the possibility of pursuing graduate education in physics with anyone?* 3) *What would you say are the biggest challenges to someone deciding to pursue graduate education after finishing a bachelor’s degree?* 4) *What would you say are the biggest obstacles to students getting accepted into graduate physics programs?* and 5) *Did you seek out any help on how to prepare an application to graduate school?* If students did not mention one of the themes identified in Phase 1 of the study, they were specifically asked for their thoughts concerning that theme. Excerpts from student interviews were selected to supplement the themes found in Phase 1 and provided the nuanced descriptions necessary for understanding the perspectives of the participants.

III. FINDINGS

The analysis of the application responses highlighted five themes related to barriers to applicants applying directly to physics graduate programs: (1) the Graduate Record Exams (GRE), (2) student research experience, (3) student grades or GPA, (4) deadlines/timelines for applying to physics graduate programs, and (5) financial concerns. These themes emerged most frequently in the analysis of responses, meaning that the participant responses explicitly related to these themes most often. Subsequent analysis of the interviews supported the identification of these themes and provided additional insight into applicant perspectives.

1. The Graduate Record Examination

The most common theme mentioned was the Graduate Record Examination (GRE). The word GRE occurred 27 times in the APS-BP applications between 2014 and 2016. Most references to the GRE did not specify whether the applicant was referring to the Physics GRE (the Subject Test) or the General GRE, unless a student specifically discussed their scores on the GRE as being a deterrent. For example, one student wrote, *“There is needed improvement in my Physics GRE and General GRE.”* The GRE code was often combined with other codes to capture multiple themes. For example, many students who mentioned the GRE also discussed paying for the GRE as a barrier to them applying to graduate school. One student wrote, *“I haven’t taken the GRE for economical [sic] problems.”* Another student wrote, *“It was a money issue. I did not have to [sic] the money to apply or even take the GRE.”* The GRE code was also often combined with codes for deadlines/timelines as well. For example, one student wrote, *“Was not able to take the GREs in time for the PhD programs.”*

Interview data supplemented findings from the content analysis regarding the subject and the general GRE. When asked about the biggest challenge to pursuing graduate education in physics, one interviewee said, *“I feel like the hardest thing is the [general] GRE. I hate the thought of*

standardized [tests] telling me if I'm competent enough to get into a program."

Both the general and subject GRE served as a barrier to students applying to graduate physics programs. Multiple interviewees described the GRE causing them anxiety and/or stress. They also mentioned taking it multiple times and performing poorly. One participant said, *I took it [the Physics GRE] ...three times...and ...[I wasn't]...happy with those scores...I prepared so much and I was ready and I didn't do well...and the General GRE...I knew there were programs that could help but they were expensive...I'm already investing [money to take the test].*

The perception of these students is consistent with recent studies regarding the General and Physics GRE. Miller and Stassun note that "the GRE is a better indicator of sex and skin colour than of ability and ultimate success" and having the GRE as an admissions requirement in US Graduate schools "severely restricts the flow of women and minorities into the sciences." [13] Miller and Stassun suggest institutions diminish the reliance on the GRE and modify admissions practices. These findings indicate that disappointment with Physics and General GRE scores and how they will be used in admissions and financial inability to pay for the tests and/or courses to help prepare for the test are barriers to ethnic/racial minority students applying to graduate school. Students believe that admissions committees take poor test scores as indicating they are incompetent. For these students who are also of low socioeconomic status their financial situation is a hindrance to them being able to participate in GRE preparatory courses and take the tests multiple times.

2. Research Experience

The second most common theme from the content analysis was related to lack of research experience. This phrase occurred 24 times. Although often referenced, comments on the application related to this theme were often brief. Students simply wrote "no research experience" or "Based off of my grades and no research experience I didn't think I would be accepted." Thus, the excerpts from the interviews were used to better understand how concerns related to research experience could be a barrier to students applying to graduate physics programs.

Student interviews revealed some reasons why students may not have had the opportunity to do research during their undergraduate career. One student mentioned lack of research experience as a barrier for his friends. He said, *"Some friends... felt scared to apply to a program and not be accepted because their research experience was not enough, and in a sense it's kind of true because in grad school you do mostly research, but I mean, I guess not everyone has the same opportunity. I feel like I was lucky... a lot of the students that don't have the good grades... don't get to do REUs which in turn, don't get the research experience."* The relationship between opportunities to do

research as undergraduate students and grades was often referenced. Thus, students felt grades had both a direct and indirect impact on their chances of getting accepted into graduate school.

Some students interviewed indicated that they felt research experience was probably one of the most important factors determining admissions to graduate physics programs. One such student mentioned applying to the school where he completed an REU. He said, *"I figured that it was so competitive that I should apply to the school where I did my REU and that might give me a chance to be accepted."* So, that was the only school to which he applied. When he was not admitted to that school, he concluded that if he could not get accepted there, he would probably not be accepted anywhere else. So, he did not apply to any other schools. Findings related to this theme indicated that low GPAs, lack of awareness regarding opportunities, and financial commitments during the summer prevented students from gaining the research experience they felt was necessary to be accepted into graduate physics programs and, thus, they did not apply. Previous studies illustrate that research experience is crucial to continued pursuit of graduate school in STEM fields for a number of reasons. Undergraduate research experiences increase understanding, confidence, and awareness, clarifies interest in STEM careers, and increases participants' anticipations of a PhD. [14]

3. Grade Point Average or Grades

Grade point average (GPA) or grades emerged as themes in the application 19 times. Although grades are important, they do not always tell the full story regarding a students' potential. Responses indicated that some students worried their GPA would prevent them from being admitted to a program and thus, did not apply. One student wrote, *"I do not meet the GPA requirement for any graduate programs I have encountered."* Another student wrote, *"My GPA is poor and I do not think I have the chance to get into a good program."* Interviews revealed similar perceptions of GPA being an important aspect of admissions decisions. One interviewee described transferring from a community college to a research university and earning a grade of "F" in a math course and barely passing his physics course. The next semester, he turned things around by learning how to study and balance his course load, but felt that an "F" on his transcript would prevent him from being accepted into any schools. He said, *"I think...because of my grades...having an F in my transcript...and maybe even GRE scores...you kind of tell yourself that you're not smart enough to get into that program because your grades reflect how smart you are. I mean that's definitely not true but that's basically what...I think admissions think [sic] about me."* Many first-generation college students and transfer students struggle during their first year at their new institution while they are getting acclimated to the new academic environment.

However, these students have also demonstrated that they can be successful in college and that the initial setbacks are not a reflection of their potential. Examples of this have been shared with the APS-BP.

4. Deadlines/Timelines

Missed deadlines or concerns regarding timelines emerged as themes in the applications eleven times. Most responses indicated that the student did not apply because they missed application deadlines or that they did not take the GRE in time for applications. In interviews, students discussed the challenges of preparing application materials and arranging for letters of recommendation while focusing on their senior year courses. One student said, *“Even though my professors had talked to me about graduate school...I didn’t realize that the deadlines were in the first semester of my senior year....but that was my fault for not taking more heed...”* Multiple interviewees mentioned having trouble finding sufficient time to study for classes, study for the GRE, and prepare application materials. Many students indicated the need for more direction on creating a timeline for preparing to apply to graduate school.

5. Financial Concerns

Financial concerns emerged as a theme 6 times. Some described financial concerns as being related to application fees or paying to take the GRE test. Other participants discussed paying off debt from undergraduate education or not knowing how to finance their graduate education. In the interviews, participants expounded on these topics. One student said, *“I think that the first challenge that comes across my mind is just financial. Sometimes you want to keep going on what...you really want to do, but you have your family that need so much support.”* Regarding financing graduate education, one student said, *“in the beginning, I didn’t know that I was going to be paid to go to grad school and so after I learned that was less of a worry...”* Financial struggles within the family may result

in students being encouraged by family members to pursue graduate school later in life. For students of low socioeconomic status earning income to support themselves and their families can prevent them from applying to graduate school.

IV. IMPLICATIONS

In this study, we describe a number of barriers that keep students from applying to graduate school. Student ideas about the use of the GRE in admissions decisions serve as particularly burdensome barriers to applying and are also consistent with admissions practices at a number of physics graduate degree-granting institutions. Graduate programs that reduce the reliance on any single measure including the GRE, research experience, and other criteria may attract a more diverse pool of applicants. Reviewing applications with an understanding that initial setbacks are not indicative of potential may also help. Financial burdens present challenges for students at several steps, including gaining research experience, preparing for and taking GRE tests, applying to graduate programs, and deciding whether or not it is worth it to attend graduate school. Many ethnic/racial minority students that are also first-generation college students often have to support their families who may discourage them from applying. Undergraduate advisors can support students by helping them understand how to select appropriate programs to which they should apply, informing students about how PhD programs in physics are financed, and giving them guidance on setting a timeline and preparing applications to graduate school.

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